Infrared (IR) Spectroscopy with the SFH 473X - Background & Technology

Application note

1 Introduction

Imagine you can check if the mangos on the market are sweet - without even touching them…
Imagine you can verify if your prescribed medical tablets contain the life-saving compound – or if they are counterfeits…
Imagine you can check the calories of your favorite cheese dish – before eating…
Imagine all this is possible with one fingertip on your smartphone…

The SFH 473X series is precisely designed to support this innovation. This note covers briefly the background of spectroscopy and the case for the SFH 473X series.

2 Infrared (IR) Spectroscopy

To identify an unknown compound the method of molecular spectroscopy based on infrared light can be used.

The physical principle is as follows:

Every molecule consists of several atoms. The bonds between the atoms can be excited by light with a characteristic wavelength (i.e. color). This leads to short time vibrations within the molecule (see Fig. 1). This characteristic wavelength depends on the strength of the bonds and the mass of the atoms and is very unique for each molecule. Since no two organic compounds have the same characteristics they can be identified with certainty by analyzing its absorption spectrum (see Figs. 2 and 3) and matching it with a database.

The most simple and natural system is the combination of sunlight and the human eye

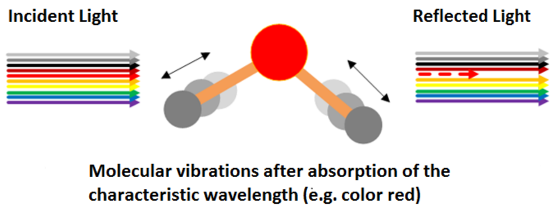

Fig. 1: *Only the characteristic wavelength will be absorbed by the molecule and leads to short term vibrations. This wavelength is unique and kind of "fingerprint" for the particular molecule / compound.*

(see Fig. 4). The sun acts as a "broadband" light source. It shines on e.g. roads and plants. Leaves absorb every color of the sunlight, except the green color (which gets reflected off the leaves). Then the human eye, acting as a wavelength selective detector (detecting blue, green and red, analogous to today's digital cameras), receives (i.e. sees) only the green light. Thus we – as a human database – identify the leaf as green and usually (in combination with our knowledge) identify it as a leave. This is different to a dry brown leaf, which reflects different colors.

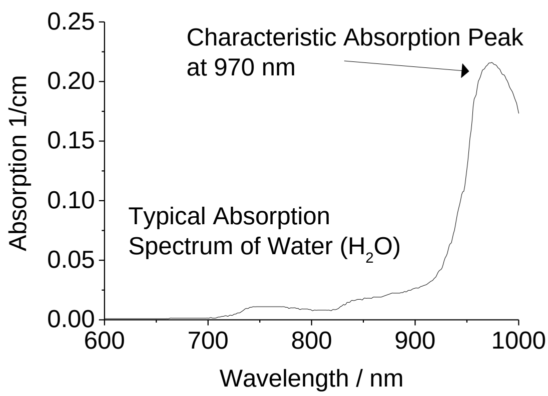

Fig. 2: *Typical absorption spectrum vs. wavelength of pure water (H_2O) in the near-IR region. The peak at around 970 nm is characteristic for pure water.*

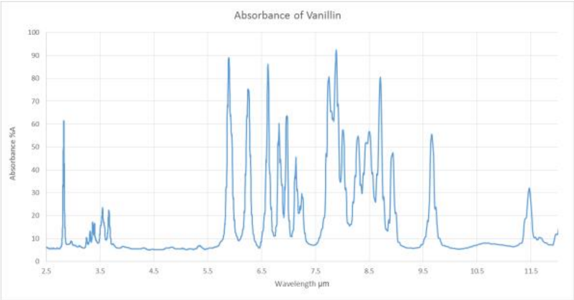

Fig. 3: *Typical absorption spectrum vs. wavelength of pure vanillin (mid IR region).*

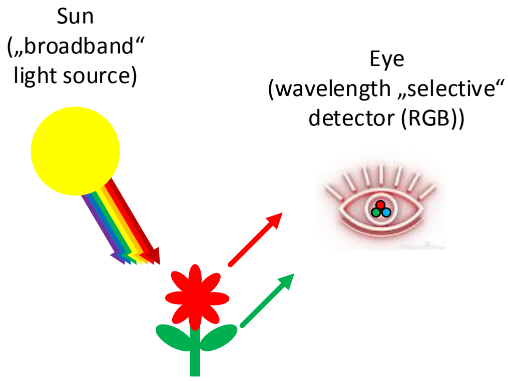

Fig. 4: *Kind of "natural" spectroscopy system.*

A simple technical realization of such an infrared spectroscopy system is presented in Fig. 5. It is an arrangement which works in transmission through the unknown compound. Alternative systems work in reflective mode.

3 System Components

There are several key components in such a system: The light source, the wavelength selective detector and the database to match the measured spectrum to identify the molecule.

The wavelength sensitive detector can be a (micro-) spectrometer with gratings to separate the wavelengths, a large monochromator or even a tiny photodiode array (e.g. CMOS camera chip) with wavelength selective filters on top of it (see Fig. 6).

In traditional systems often light bulbs are used as their black body radiation is very broad and covers a wide wavelength range. However, light bulbs are bulky and have limited lifetime. While this is fine with laboratory instruments it is a blocking point for developing tiny handheld-style spectrometers.

To solve this problem, OSRAM has developed a novel LED-based light source to enable development of ultra-compact IR-spectrometers which fit in smartphones or USB sticks.

Key requirements for such a solid-state broadband light source are:

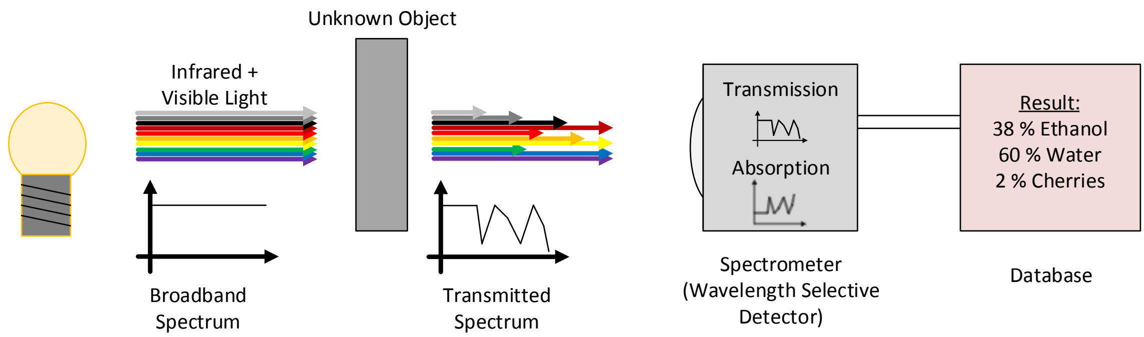

Fig. 5: *Basic block diagram of a spectroscopy system. The light source is a broadband traditional light bulb which emits light from visible into the infrared region. For near-IR systems the lamp can be replaced with the new SFH 473X series.*

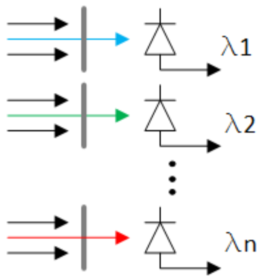

Fig. 6: *Simplified block diagram of a wavelength selective photodiode array based on selective filter elements.*

- **broad wavelength range:** *Covering the near-IR range from 700 nm – 1100 nm matching perfectly the sensitivity of low-cost silicon-based detectors.*
- **smooth spectrum:** *Covering the near-IR range with a stable spectrum without major dips and peaks.*
- **long lifetime:** *No replacements of the light source anymore. This allows very compact module designs.*
- **compact size:** A*llowing of ultra-compact spectrometers for implementation in smart phones.*
- **blue background light:** *Allowing the user to identify which material or location is scanned and analysed. The stylish blue light has same angular radiation characteristics as the invisible IR light.*
- **small emitting size:** *A small emitting size (small etendue) vs. traditional light sources allows compact optics for tiny modules.*
- **fast modulation capability**: *Allowing modulation and short on-times to save valuable battery power vs. traditional light sources (even allowing compensation for ambient light).*
- **high efficiency:** *Particular suited for mobile applications to save battery power.*
- **wide operating temperature range:** *Allows operation without active cooling (fan) for tiny module design.*
- **low cost:** *Opens up new markets for spectroscopy. Bringing down system costs from thousands of US$ to single digit US$.*

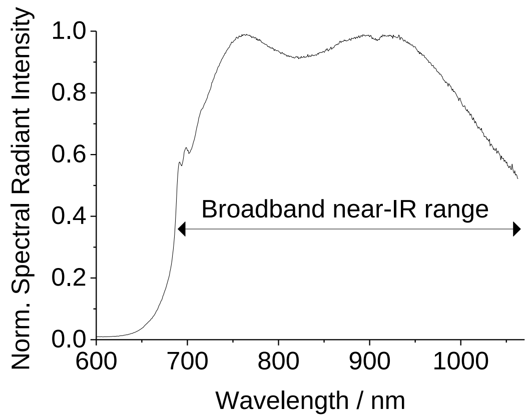

Fig. 7: *Typical spectrum of the broadband near-IR LED SFH 4735.*

The mentioned requirements are all met by the new broadband near-IR light sources from OSRAM.

Fig. 7 presents the typ. spectral radiant intensity of the SFH 473X. The spectral range has been designed to cover the complete near-IR range from 700 nm to 1100 nm to match the sensitivity of low cost Si-based detectors (e.g. modified CMOS-based camera sensors).

The products are based on state-of-the-art OSRAM conversion technology and come in two product variations, the SFH 4735 and the SFH 4736 with lens for narrow angle applications (see Fig. 8).

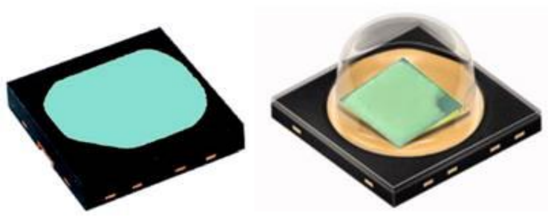

Fig. 8: *Photography of the SFH 4735 (no lens) / SFH 4736 (with lens).*

Appendix

Don't forget: LED Light for you is your place to be whenever you are looking for information or worldwide partners for your LED Lighting project.
www.ledlightforyou.com

Author: Dr. Hubert Halbritter

DISCLAIMER

This document is for information purposes only and does not represent a specification or a warranty.
All information contained in this document has been collected, analyzed and verified with great care by OSRAM Opto Semiconductors GmbH. However, OSRAM Opto Semiconductors GmbH can neither warrant the correctness and completeness of the information contained in this document nor can OSRAM Opto Semiconductors GmbH be made liable for any damage that occurs in connection with the use of and/or the reliance on the content of this document. The information contained in this report represents the state of knowledge as of February 2014 and is subjected to change without notice.

About Osram Opto Semiconductors

Osram Opto Semiconductors GmbH, Regensburg, is a wholly owned subsidiary of Osram GmbH, one of the world's three largest lamp manufacturers, and offers its customers a range of solutions based on semiconductor technology for lighting, sensor and visualisation applications. The company operates facilities in Regensburg (Germany), Sunnyvale (USA) and Penang (Malaysia). Further information is available at www.osram-os.com.
All information contained in this document has been checked with the greatest care. OSRAM Opto Semiconductors GmbH can however, not be made liable for any damage that occurs in connection with the use of these contents.